



**US Army Corps
of Engineers®**

Engineer Research and
Development Center

Monitoring Completed Navigation Projects (MCNP) Great Lakes Armor Stone Study

Problem

Degradation of armor stone protection used in Great Lakes coastal navigation projects may occur because of a number of interacting and interrelated factors, rather than a single major cause. The need exists for a better understanding of the relationship between the standard laboratory tests used in stone specifications and the observed performance of armor stone in the structures. Research to meet this need calls for the comparisons of field performance observations and laboratory test data of similar stones.

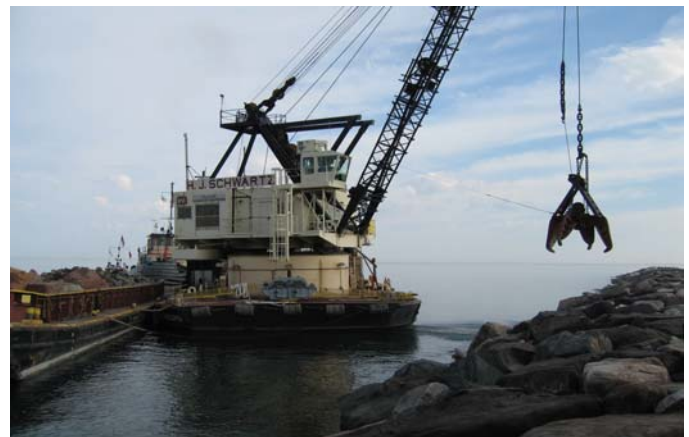


Burns International Harbor, Indiana

Previous studies have evaluated stone deterioration, based on comparison of different types of stone used in different structures. Much of the testing performed on stone submitted as material for erosion protection is based on the protocols used to evaluate concrete aggregate and subgrade stone materials—that is, tests designed for use on material orders of magnitude smaller than armor stone of several tons. Acceptance of sources is then based on a combination of test results, performance records, and quarry inspections.

Research Approach

This project, the Great Lakes Armor Stone Study, is one of the U.S. Army Corps of Engineers' Monitoring of Completed Navigation Projects (MCNP) research program. During the initial phase of this project in 2005, three sites (Burns Harbor, Cleveland Harbor and Keweenaw Waterway) were nominated by each participating District (Buffalo, Chicago and Detroit Districts). The histories of the three project-sites were summarized by representatives of the respective districts involved (i.e. Buffalo District-Cleveland Harbor, Chicago District-Burns Harbor and Detroit District-Keweenaw Waterway). The sources of stone used in the projects was identified and visits to each of the quarries and project sites conducted on order to familiarize the team with the projects, their stone sources and the surrounding geologic environments. Dates of quarrying, rock type, and sufficient initial construction documentation (photographs and descriptions of initial condition of armor stone), and an initial site survey was conducted in order to select the test sites and potential stones for long-term monitoring. Sites where previous investigations (MCCP program or periodic inspections) indicated significant deterioration were reviewed with respect to the rock type and test results and these areas will be considered for inclusion into this research effort.



Wave height and temperature data will be reviewed to evaluate links between these factors and stone performance. Data on lake ice will also be considered in the final review of considerations for stone durability. Ultimately this project will involve bench-scale (laboratory) tests, field observations (quarterly monitoring) of stone deterioration, and numerical modeling. Correlation will be made between these different scale data sets, and an empirical stone deterioration model will be developed to evaluate armor stone performance more accurately.

Long-term performance or deterioration of armor stones (index stones selected for this study) will be monitored quarterly and any changes in dimensions measured. Qualitative observations will be documented and samples photographed with each inspection. By using index stones cut to the same dimensions and subjected to the same testing in the lab stones from different quarries and rock types (and excavation methods) can be compared objectively. Observations and data comparisons between stones at the quarry versus in-place stones in existing shoreline projects will provide further information for use in considering the potential differences between field performances, laboratory testing and numerical simulations.

Final Products

Research results will be published in an ERDC technical report and peer-reviewed journal articles and will include a combined review of the collected data and that of previous studies regarding the importance and controlling factors related to armor stone durability. These reports will also summarize the investigation of laboratory test methods used—both ASTM and modifications to those procedures—and possible recommendations with respect to more applicable testing for armor stone. A guide specification (in Specsintact format) will be included as an appendix.

Potential Users

The MCNP Program findings apply to completed projects operated and/or maintained by the U.S. Army Corps of Engineers Districts and Divisions nationwide.

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